Deep Space Network Operations and Maintenance

Request for Proposal

Industry Briefing

February 18-20, 2003

National Aeronautics and Space Administration

California Institute of Technology
4800 Oak Grove Drive
Pasadena, California 91001

Joseph A. Wackley
Operations

Agenda

- **What the DSN is…**

- **Where the Contractor fits…**

- **What the Contractor does for JPL…**

What the DSN is...

Deep Space Network

- **The Deep Space Network is a unique, worldwide network of spacecraft tracking facilities**

- **Sites are located at Madrid, Spain; Canberra, Australia and Goldstone to allow continuous view of deep space, ecliptic missions**

- **The DSN is solely responsible for navigation, command and data acquisition for NASA high earth orbiters and deep space missions**

  - **Also tracks low earth spacecraft in emergencies and (sometimes) DoD spacecraft**

  - **Mission set includes approximately 50-60 spacecraft tracked on a regular & emergency basis and includes spacecraft more than 12 billion kilometers from earth -- round trip signal time is more than 23 hours!**

  - **Number of spacecraft is largest in NASA history and increasing**

  - **More than 1300 scheduled events every month**

  - **Similarly, number, length and complexity of critical event supports is increasing**

Deep Space Network (2)

- **The DSN additionally tracks non-NASA spacecraft launched by other spacefaring nations such as Japan, U.K., Germany, Italy, France and Russia**

Tracking Environment

- **DSN operates at 1.6-1.7 GHz (L), 2.0-2.3 GHz (S), 7.1-8.5 GHz (X) and 31-35 GHz (Ka)**

  – **Eventually will have optical communications capability and 37-38 GHz communications for human exploration of Mars**

- **DSN sites can have transmitter powers of up to 400KW at S-Band; 20KW at X-Band; and 50 watts at Ka-Band**

  – **Radar radiates at 500KW at 8.6 GHz**

- **Deep space spacecraft typically have transmitter powers of approximately 10 watts**

- **Distances and small spacecraft antennas result in extremely weak received signal conditions**

Characteristics of Deep Space Missions

Received Signal Sensitivity:

The received energy from Voyager at Neptune, if integrated for 300 million years, would be just enough to set off a small photographic flashbulb!

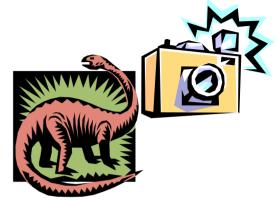*Received power = 10^{-17} Joules/sec*

Command Power:

The DSN puts out enough power in commanding Galileo that it could easily provide high quality commercial TV at Jupiter!

Transmitted power = 400 kW

Dynamic Range of the DSN:

The ratio of the received signal power to the DSN transmitting power is like comparing the thickness of a sheet of tissue paper to the entire Earth!

Ratio = 10^{27}

Characteristics of Deep Space Missions

Navigational Accuracy:

Voyager navigation at Neptune was equivalent to being able to tee – off from California and place the ball on a green in Washington, D.C.!

Angular accuracy = 50 nrad

14,000 Km

Frequency Stability:

The DSN's ionic clocks used to achieve this navigation accuracy are so stable that only one second of error would accumulate every 30 million years!

Allan variance = 10^{-15} in 1000 seconds

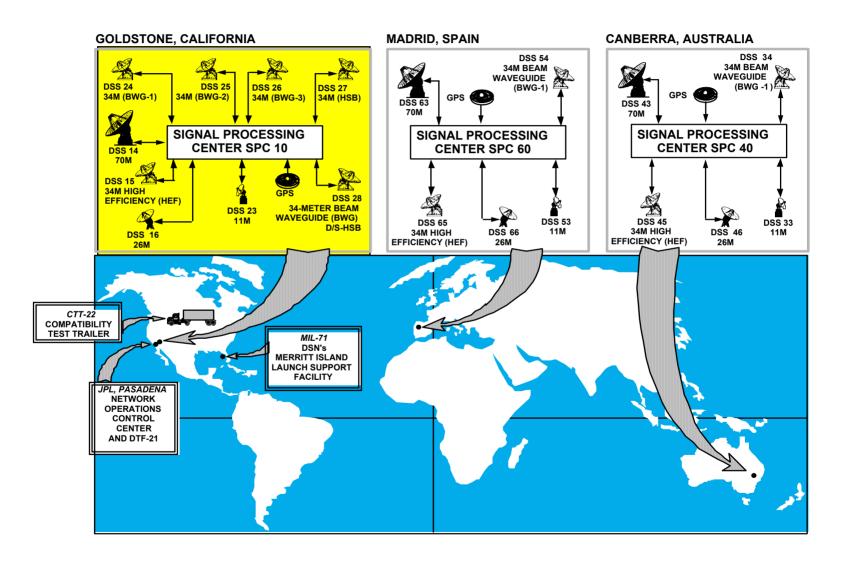**Once-in-a-lifetime Science Opportunities:**

The data from a planetary encounter is priceless. The reliability of a spacecraft and the DSN together is equivalent to driving an automobile for 3 billion miles without a single failure!

DSN Facilities

GOLDSTONE, CALIFORNIA

DSS 24 34M (BWG-1)
DSS 25 34M (BWG-2)
DSS 26 34M (BWG-3)
DSS 27 34M (HSB)

DSS 14 70M

SIGNAL PROCESSING CENTER SPC 10

DSS 15 34M HIGH EFFICIENCY (HEF)
DSS 23 11M
GPS
DSS 28 34-METER BEAM WAVEGUIDE (BWG) D/S-HSB
DSS 16 26M

MADRID, SPAIN

DSS 63 70M
GPS
DSS 54 34M BEAM WAVEGUIDE (BWG-1)

SIGNAL PROCESSING CENTER SPC 60

DSS 65 34M HIGH EFFICIENCY (HEF)
DSS 66 26M
DSS 53 11M

CANBERRA, AUSTRALIA

DSS 43 70M
GPS
DSS 34 34M BEAM WAVEGUIDE (BWG -1)

SIGNAL PROCESSING CENTER SPC 40

DSS 45 34M HIGH EFFICIENCY (HEF)
DSS 46 26M
DSS 33 11M

CTT-22 **COMPATIBILITY TEST TRAILER**

MIL-71 **DSN's MERRITT ISLAND LAUNCH SUPPORT FACILITY**

JPL, PASADENA **NETWORK OPERATIONS CONTROL CENTER AND DTF-21**

DSN Facilities (2)

Madrid
Operated by
INSA for INTA

Canberra
Operated by
Raytheon
for CSIRO

Goldstone

DSN Facilities (3)

- **Goldstone Deep Space Communications Complex is the keystone of the DSN**

  – **Largest site with the most antennas: 70m, five operational 34m's, 26m, R&D 34m and 11m and a 34m radio telescope used for educational outreach (including DoD dependent education)**

  – **One 34m includes a radio science system that provides the most stable system ever built and is used for gravity wave detection experiments**

- **GDSCC serves also as a center of DSN research and development due to its proximity to JPL (the 150 mile screwdriver)**

  – **Installation of new technology and prototype developments to verify system performance**

  – **First article installations**

- **GDSCC is considered a National Resource by an act of Congress and is in an environmentally sensitive area**

DSN Facilities (4)

- **Additionally, Goldstone performs continuous wave radar observations of near Earth asteroids, other natural objects and planets**

  - **Uses high power radiation of up to 500KW with extremely weak return signals**

  - **Asteroid tracking is particularly important because of short times from discovery to tracking and extreme public interest**

- **Goldstone is operated and maintained by the DSN M & O contractor**

DSN Facilities (5)

- **Other Contractor-operated DSN facilities include:**

    - **MIL 71:** located at MILA; staffed as required for spacecraft compatibility verification and pre-launch testing

    - **DTF 21:** located at Bldg. 605 just south of JPL; supports compatibility testing and development testing

    - **CTT 22:** a mobile compatibility test trailer; supports RF and data compatibility tests

    - **Central Communications Terminal:** Bldg. 230; provides voice and data communications interconnections

    - **Deep Space Operations Control Center:** Bldg. 230; provides support data and technical information to the DSCC's and projects and processes data for delivery to projects

    - **Remote Operations Support Area: at Bldg. 507 (CSOC Facility);** supports mission critical events

    - **DSN Logistics Facility: at Bldg. 504 (CSOC Facility);** supports modkit handling, inventory and shipping/receiving, and vendor repair
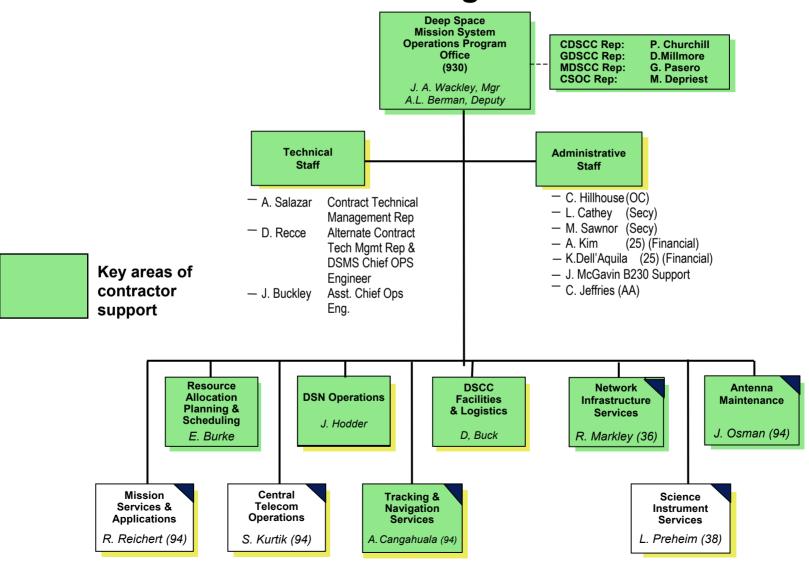
Where the Contractor fits...
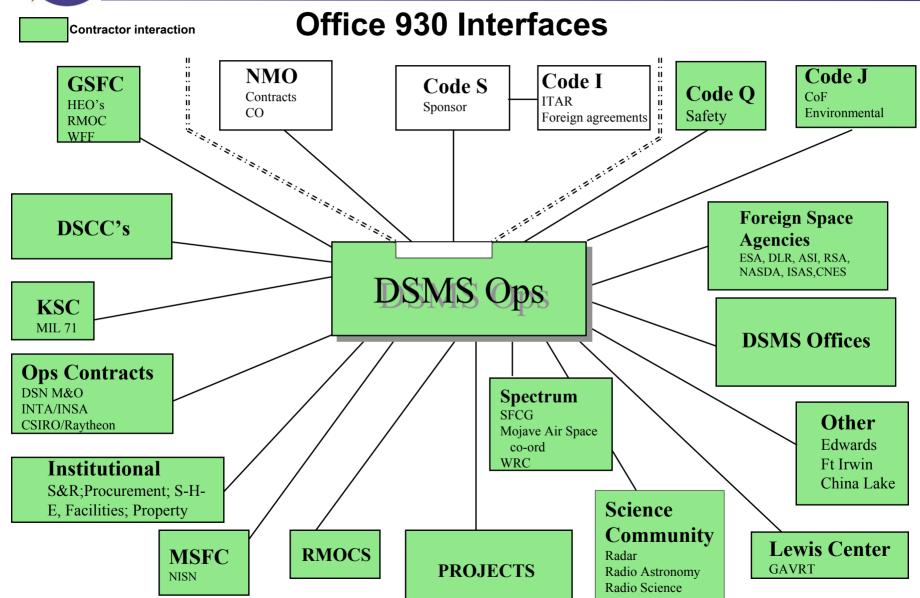
Office 930

- **The DSMS Operations Program Office (930) is responsible for the maintenance and operations of the DSN**

- **Office 930 is programmatically responsible for the DSN M&O contract**

  - **Includes responsibility for contract performance evaluation, areas of emphasis, POP generation, as well as, technical areas**

  - **Contract Technical Manager and assistant are also in 930**

- **DSN M & O contractor personnel are in Office 930**

  - **Shown as 930 affiliates for security, badging, X.500 listing, on-site telephones, and other services**

  - **There is extensive interaction between JPL/930 and the contractor at all levels of the organization**

- **The contractor represents Office 930 to many external space agencies, state & local agencies, other DSMS offices, other DSCC's, other NASA centers, U.S.Armed Forces**

Shared Appointment with
DSMS Engineering Office

Office 930 Organization

Deep Space Mission System Operations Program Office (930)

J. A. Wackley, Mgr
A.L. Berman, Deputy

CDSCC Rep:	P. Churchill
GDSCC Rep:	D.Millmore
MDSCC Rep:	G. Pasero
CSOC Rep:	M. Depriest

Technical Staff

— A. Salazar — Contract Technical Management Rep
— D. Recce — Alternate Contract Tech Mgmt Rep & DSMS Chief OPS Engineer
— J. Buckley — Asst. Chief Ops Eng.

Administrative Staff

— C. Hillhouse (OC)
— L. Cathey (Secy)
— M. Sawnor (Secy)
— A. Kim (25) (Financial)
— K.Dell'Aquila (25) (Financial)
— J. McGavin B230 Support
— C. Jeffries (AA)

Key areas of contractor support

Resource Allocation Planning & Scheduling
E. Burke

DSN Operations
J. Hodder

DSCC Facilities & Logistics
D, Buck

Network Infrastructure Services
R. Markley (36)

Antenna Maintenance
J. Osman (94)

Mission Services & Applications
R. Reichert (94)

Central Telecom Operations
S. Kurtik (94)

Tracking & Navigation Services
A. Cangahuala (94)

Science Instrument Services
L. Preheim (38)

Office 930 Interfaces

Contractor interaction

GSFC
HEO's
RMOC
WFF

NMO
Contracts
CO

Code S
Sponsor

Code I
ITAR
Foreign agreements

Code Q
Safety

Code J
CoF
Environmental

DSCC's

Foreign Space Agencies
ESA, DLR, ASI, RSA,
NASDA, ISAS,CNES

KSC
MIL 71

DSMS Ops

DSMS Offices

Ops Contracts
DSN M&O
INTA/INSA
CSIRO/Raytheon

Spectrum
SFCG
Mojave Air Space
 co-ord
WRC

Other
Edwards
Ft Irwin
China Lake

Institutional
S&R;Procurement; S-H-
E, Facilities; Property

MSFC
NISN

RMOCS

PROJECTS

Science Community
Radar
Radio Astronomy
Radio Science
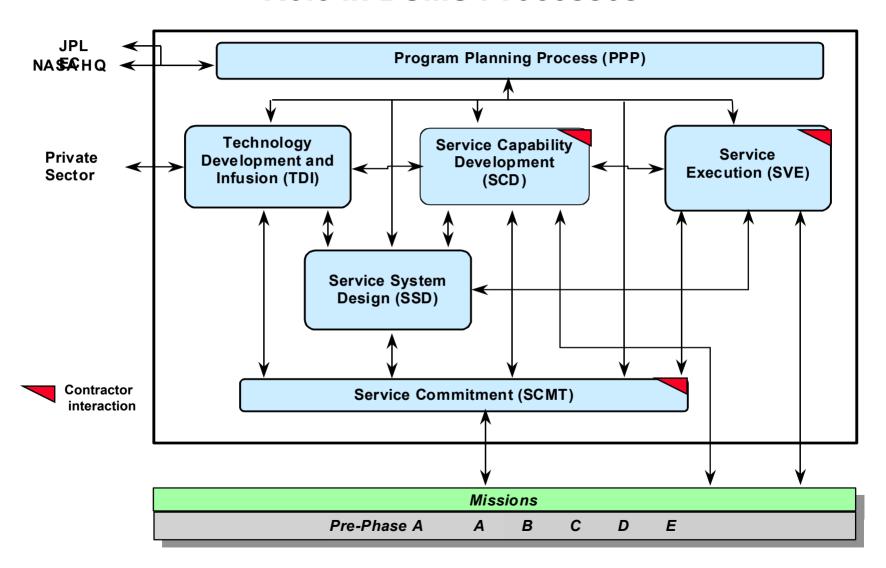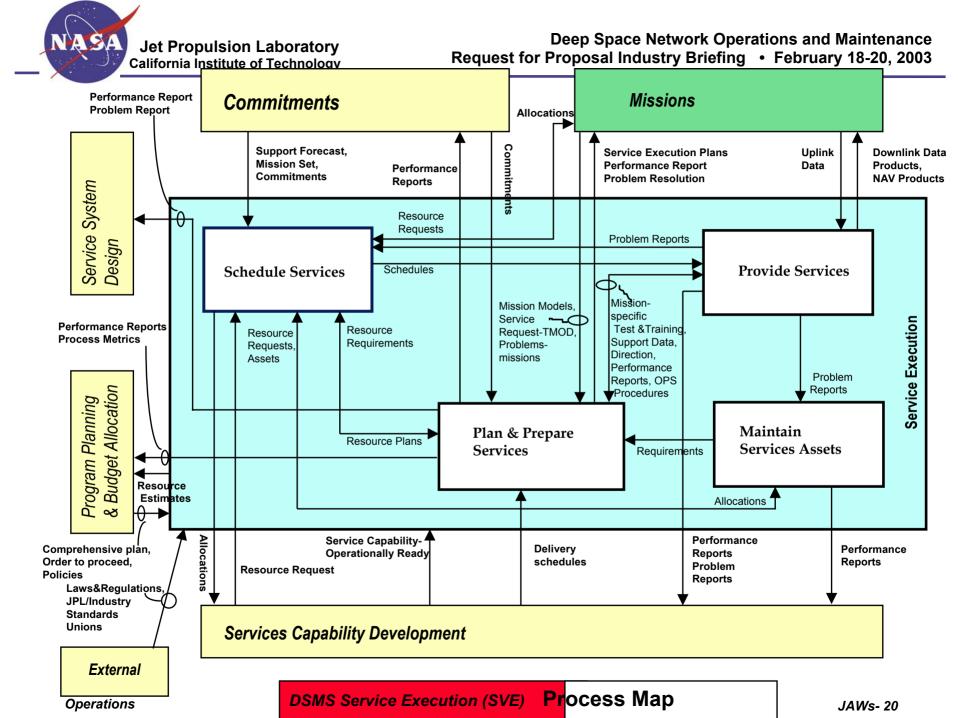
Lewis Center
GAVRT

Role in DSMS Processes

- **The contractor is a participant in most DSMS Processes**

    - **Participates in all activities within the Service Execution process**

    - **Active participation in appropriate activities in Service Capabilities Development (KRK to discuss) and Service Commitment processes**

Role in DSMS Processes

Commitments

Missions

Performance Report
Problem Report

Allocations

Service System Design

Support Forecast,
Mission Set,
Commitments

Performance
Reports

Commitments

Service Execution Plans
Performance Report
Problem Resolution

Uplink
Data

Downlink Data
Products,
NAV Products

Resource
Requests

Problem Reports

Schedule Services

Schedules

Provide Services

Mission Models,
Service
Request-TMOD,
Problems-
missions

Mission-
specific
Test &Training,
Support Data,
Direction,
Performance
Reports, OPS
Procedures

Resource
Requests,
Assets

Resource
Requirements

Performance Reports
Process Metrics

Program Planning & Budget Allocation

Resource Plans

Plan & Prepare Services

Requirements

Maintain Services Assets

Problem
Reports

Resource
Estimates

Allocations

Comprehensive plan,
Order to proceed,
Policies

Laws&Regulations,
JPL/Industry
Standards
Unions

Allocations

Resource Request

Service Capability-
Operationally Ready

Delivery
schedules

Performance
Reports
Problem
Reports

Performance
Reports

Services Capability Development

External

Service Execution

Operations

What the Contractor does...

O&M Definition

- **Operations includes work and resources related to meeting project requirements**

  - **DSN is composed of facilities, hardware, software, and personnel:**

    - **Canberra, Madrid and Goldstone Deep Space Communication Complexes operations**

    - **Safety, health and environmental activities**

    - **Site security -- DSCC's are considered National Resources**

    - **DSN supporting facilities**

    - **Multi-mission Navigation Operations**

    - **Communications**

    - **Host Country Radio Astronomy and Goldstone Solar System Radar**

    - **Management and administrative support**

    - **Interface with contractor and DSCC management, foreign agency contract management and NASA contract and technical management**

O&M Definition (2)

- **Maintenance includes work and resources for maintaining the DSN facilities in an operational condition-- comparable to a small town's public works department-- "roads & commodes"**

- **Maintenance includes:**

  - **All equipment and facilities at the DSCC's**

  - **Spares**

  - **Support equipment**

Contractor Functions

- **In the performance of the DSN M & O contract, the contractor will support the overall goals of the DSMS and the DSN in the following key areas:**

  - **Contract program management**

  - **GDSCC realtime operations and maintenance**

  - **GDSCC support of radar and radio astronomy operations and research**

  - **GDSCC antenna and facilities maintenance**

  - **GDSCC equipment repair (e.g. CMF)**

  - **Network and data system operations**

  - **Development and sustaining of specified data systems**

  - **Test engineering support for all DSN software**

  - **Installation, integration and test of new hardware and software**

  - **Data analysis and problem resolution**

  - **Detailed mission preparation planning and mission support**

  - **Logistics and materiel support**

Contractor Functions (2)

- **The TDD (included in the RFP package) provides a functional description of all work to be performed and requirements for performing it.**

Contractor Functions (3)

- **The contractor:**

  - **Provides direct operations support to DSMS Engineering development tasks**

    - **Engineers work as members of development tasks to develop Operations Test Plans; define spares requirements; assist in preparation of modkits; ship modkits;support pre-acceptance and perform acceptance tests; support integration, installation and test; analyze problems and provide technical assistance to the network**

    - **CDE's for designated software and hardware assemblies**

    - **Personnel and equipment to support on-site hardware and software installation, integration and test**

    - **Operate the DSN software and documentation control processes and libraries**

    - **Develop operations procedures**

Contractor Functions (4)

– **Performs test and training in preparation for new mission supports or critical activities**

  • **Provide mission support engineers who support development tests; develop network preparation plans, critical event plans, write Network Operations Plans; execute data flows, project-dependent tests (MSTA's, GDST's and ORT's) ; coordinate support requirements with projects; support critical events and special activities; monitor DSN performance**

Contractor Functions (5)

- **Additional Contractor functions include:**

  - **Scheduling the network and supporting resources -- resource loading assessments; resource allocation; contention/conflict resolution; generate 8 week and 7day schedules; communications scheduling**

  - **Executing scheduled events and monitor performance -- spacecraft tracking, VLBI, radio astronomy, radar astronomy**

  - **Conditioning radio metric data -- ensure data are correct; compute observables; ensure data quality**

  - **Generating calibration data -- ionosphere and troposphere delays; timing and polar motion; reference frequency and time**

  - **Analyzing and recovering from anomalies -- approximately 300 Discrepancy Reports opened every month**

Contractor Functions (6)

- **Contractor functions include(cont'd):**

  - **Maintaining and repairing all transferred hardware**

    - **Everything from antennas, amplifiers, transmitters, to computers**

    - **Use site personnel plus vendor repair**

  - **Performing routine and periodic maintenance**

  - **Developing required support capabilities including:**

    - **SPT; analysis tools; equipment diagnostic tools; etc.**

  - **Maintaining the GAVRT antenna: DSS 12**

  - **Operating and maintaining DSS 13: R&D site**

  - **Providing GDSCC physical security**

    - **Guards, gates, fences, intrusion detection, access control for buildings and sites**

Contractor Functions (7)

- **Contractor functions include (cont'd)**

  - **Operating and maintaining supporting equipment and facilities including:**

    - **Cafeterias; plumbing; Ops and admin messaging; "roads and commodes," HVAC, power, lighting, groundskeeping, waste disposal, gas stations**

    - **Power Generation & distribution facilities: 9Mw at GDSCC**

    - **Vehicles: including transportation, cranes, forklifts, trucks**

    - **Maintenance facilities: including test equipment, equipment calibration, and repair shops**

    - **Logistics facilities**
      - **Inventory of approximately 5000+ items**
      - **Property control; including salvage and disposal**

    - **Shipping and Receiving**
      - **Handle approximately 194 tons of material annually**

Contractor Functions (8)

- **Contractor functions (cont'd):**

  - **Maintaining an active and exemplary safety, health and environmental program**

    - **Goldstone audited frequently by federal, state and local agencies (NASA, JPL, OIG, OSHA, CAL/OSHA, Fish and Game, AQMD, RWQCB) and cited frequently for outstanding performance**

  - **Coordinating activities with outside agencies**

    - **Mojave Coordination Group for RFI and Airspace coordination**

    - **Coordinate impact of military activities and use of DSN facilities by Ft. Irwin, China Lake and Edwards AFB**

  - **Operating and maintaining multiple test facilities including DTF 21, CTT 22 and MIL 71**

A Final Word

The DSN is an amazing system of precision, sensitive tracking stations, hardware, software and personnel working together to further NASA's space exploration mission of turning whispers from space into loud exclamations of scientific and technological breakthroughs

The DSN M & O contractor is *integral* and *essential* to the   success of that mission